This listing of claims replaces all prior versions, and listings, of claims.

Listing of Claims

The following listing of claims replaces the prior listing, and all prior claim listings:

Claims 1-22 (Cancelled)

Claims 23-31 (Withdrawn)

32. (Cancelled)

Claims 33-46 (Withdrawn)

47. (Currently amended) An apparatus suitable for controlling the size and the phase of an electromagnetic beam, the apparatus comprising:

a. a substrate; and

b. a vertically Graded Refractive index (vGRIN) multilayer structure ~~film~~ deposited on the substrate~~; and~~, the multilayer structure including a vGRIN film and

~~c.~~ a curved input sidewall and a curved output sidewall~~s~~, the input sidewall being ~~the~~ a sidewall on which the electromagnetic beam is incident on the apparatus, the output sidewall being ~~the~~ a sidewall through which the electromagnetic beam leaves the apparatus, wherein the apparatus is used to independently control a vertical focusing and a horizontal focusing of the electromagnetic beam.

48. (Currently amended) The apparatus as recited in claim ~~45~~ 47 wherein the curved input sidewall and the output sidewall~~s~~ comprise~~s~~:

a. at least one of a metal layer and a polysilicon layer deposited on the vertically Graded Refractive Index film; and

b. a photoresist layer spin-coated on the at least one of the metal and the polysilicon layer.

49. (Currently amended) The apparatus as recited in claim ~~45~~ 47 wherein the substrate ~~is made up~~ comprises at least one of ~~the~~ a Si, GaAs, AlN, $LiNbO_3$ and quartz compositions~~.~~

50. (Currently amended) The apparatus as recited in claim ~~45~~ 47 wherein the substrate ~~is~~ comprises a glass.

51. (Currently amended) The apparatus as recited in claim ~~45~~ 47, further comprising a waveguide operatively coupled to the apparatus, wherein ~~the~~ a connection between the apparatus and ~~a~~ the waveguide is established using photolithography.

52. (Currently amended) The apparatus as recited in claim ~~45~~ 47 wherein the apparatus is fabricated in an array form for multi-channel light coupling into or out of a multi-port photonic chip.

53. (New) The apparatus as recited in claim 47 wherein the vertical focusing is controlled by varying a thickness of the vGRIN multilayer structure.

54. (New) The apparatus as recited in claim 47 wherein the horizontal focusing is controlled by varying at least one of a radii of curvature of a surface of the curved input sidewall and a surface of the curved output sidewall.

55. (New) The apparatus as recited in claim 53 wherein a thickness of the vGRIN multilayer structure is varied by etching.

56. (New) The apparatus as recited in claim 55 wherein a radii of curvature of a surface of the curved input sidewall and a surface of the curved output sidewall is varied by etching.

57. (New) The apparatus as recited in claim 54 wherein the electromagnetic beam leaving the apparatus is a divergent beam when a thickness of the vGRIN multilayer

structure is in a range ((2n-1) x f / 4) and (n x f / 2), where f is a pitch of the vGRIN film and n is a natural number.

58. (New) The apparatus as recited in claim 54 wherein the electromagnetic beam leaving the apparatus is a convergent beam when a thickness of the vGRIN multilayer structure is in the range and (n x f / 2) and ((2n+l) x f /4), where f is a pitch of the vGRIN film and n is a natural number.

59. (New) The apparatus as recited in claim 53, wherein a surface of the curved input sidewall and a surface of the curved output sidewall comprise one of a spherical, aspherical, cylindrical or toric shapes.

60. (New) The apparatus as recited in claim 53 wherein the surface of the curved input sidewall and the surface of the curved output sidewall have a same radii of curvature.

61. (New) The apparatus as recited in claim 53 wherein the surface of the curved input sidewall and the surface of the curved output sidewall have different radii of curvature.

62. (New) The apparatus as recited in claim 61 wherein the surface of the curved input sidewall and the surface of the curved output sidewall have a positive radius of curvature.

63. (New) The apparatus as recited in claim 62 wherein the radius of curvature of the surface of the curved input sidewall and the radius of curvature of the surface of the curved output sidewall of the input sidewall have the same signs.

64. (New) The apparatus as recited in claim 63 wherein the radius of curvature of the surface of the curved input sidewall and the radius of curvature of the surface of the curved output sidewall have different signs.

65. (New) The apparatus as recited in claim 53 wherein the surface of the curved input sidewall and the surface of the curved output sidewall have arbitrary curved shapes.

66. (New) The apparatus as recited in claim 53 wherein a vertical refractive index profile of the vGRIN film comprises an arbitrary refractive index variation.

67. (New) The apparatus as recited in claim 61 wherein at least one of the curved input sidewall and the curved output sidewall comprises an anti-reflection coating.

68. (New) The apparatus as recited in claim 67 wherein the antireflection coating is designed on a basis of at least one of a central refractive index, an average refractive index, and an optimum equivalent index that leads to a maximum electromagnetic wave transmission.

69. (New) The apparatus as recited in claim 53 wherein the curved input sidewall and the curved output sidewall comprise a three-dimensional curved surface such that a radius of curvature of the curved input sidewall and the curved output sidewall diminishes with the departure from a vertical central region of the Graded Refractive Index distribution.

70. (New) The apparatus as recited in claim 53 wherein the Graded Refractive Index distribution of the apparatus is a standard distribution.

71. (New) The apparatus as recited in claim 68 wherein the Graded Refractive Index distribution of the apparatus is parabolic.

72. (New) The apparatus as recited in claim 53 wherein the electromagnetic beam leaving the apparatus has at least one of a circular spot size and an elliptical spot size.

73. (New) The apparatus as recited in claim 53 wherein a wavelength of the electromagnetic wave is in the visible range.

74. (New) The apparatus as recited in claim 53 wherein a wavelength of the electromagnetic wave is in the Radio Frequency (RF) range or in the TeraHertz range.